**Protocol for incubation and on-farm dairy cattle feeding of Urea-Molasses treated Crop Residues in Babati, Mbulu and Karatu Districts of Manyara Region, Tanzania**

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**Introduction**

Small-scale dairying is important in sustaining livelihoods in the highland areas of Eastern Africa. Dairy diets are forage based. In the past this would have been provided through grazing or, more recently by growing planted forages mainly Napier grass. However, as farm sizes decrease through inter-generational subdivision and farms intensify, farmers seek to maximize food security by growing food crops (cereals and legumes) alongside planted forage feeds such as Napier grass. For many small holder farmers, feeding dairy cattle over the dry period when forages are scarce is a major challenge. The inadequate forage feed availability and supplies on smallholder farms in East Africa is aggravated by seasonal variations in quantity and quality that causes fluctuations in animal nutrition and productivity throughout the year (Lukuyu, et al., 2010). Hence, to bridge the feed gap, most small holder farmers mainly depend on crop residues to meet the nutrient requirements of the animals.

Crop residues are roughages, potentially rich sources of energy as about 80% of their dry matter (DM) consists of polysaccharides, but usually underutilized because of their low digestibility, which limits feed intake (FAO, 2002). These poor quality roughages such as straws have the potential to improve animal feeds by employing different treatment strategies. Interestingly, China’s experience in utilizing tones of annually produced crop residues for ruminants after processing has promoted a marked increase in beef and mutton output, saving a great quantity of grain used for this purpose (Gao, 2000).

Crop residues, such as maize stover, bean haulms, sunflower straw, pigeon pea haulms, rice straw, groundnut husks, etc are abundant in the food crop growing areas (as case of Babati, Mbulu and Karatu) (Ngunga and Lukuyu, 2016), as largely underutilized by-product because of their low digestibility, which limits feed intake (FAO, 2002). However, they are potentially rich sources of energy, when chemically treated, as about 80% of their DM consists of polysaccharide, though deficient in mineral nutrients such as N, S, P and Co, which are essential to rumen microorganism function. Therefore, crop residue based diets in their natural form, cannot meet nutrient requirements of dairy cattle and often result in low milk production, sub optimal reproductive performance and general poor health.

The nutritive value of crop residues mentioned above can be improved by different methods of treatment. Urea treatment has, however, emerged as the method of choice for use at farm level in the tropics as it is best adapted to the conditions of smallholder farmers (Chenost, 1995). The major advantages of using urea for crop residue improvement are ease of handling, transport, and do not pose any risk to those handling and using it (Singh and Singh, 2003). Moreover, fertilizer grade urea is readily available and relatively cheap compared to either aqueous or anhydrous ammonia.

Additionally, the use of urea and molasses for supplementing crop residue-based diets has been well documented in ruminants (Sansoucy 1995; Garg et al 1998; Singh and Singh 2003) and has more potential to increase the viability of dairy production (Leng et al 1991; Singh and Singh 2003; Misra and Reddy 2004), to increase dry season milk supplies and increase household income (Garg et al 1998; Patel 2002; Singh and Singh 2003). Urea and molasses can be fed throughout the year but are more beneficially utilized during the dry season or when the animals are grazing low quality fodder (Bheekhee et al 2002).

It is recognized that when animals are offered a low-nitrogen, high fibre roughage, as in most cereal crop residues, one of the critical limiting nutrients is fermentable nitrogen (N) available to rumen microbes (ARC, 1984). The use of urea-molasses is a convenient way to avoid excessive intake of urea N which would result in Ammonia Nitrogen losses from the rumen, and will ensure an almost continuous supply of ammonia-N (Preston, 1986), along with readily soluble carbohydrate for microbial growth. Urea-molasses feeding has yielded positive results in many parts of the world (Kunju, 1986; Hadjipanayiotou et al., 1993; Chen et al., 1993). The main variables affecting the efficiency of urea-molasses treatment are (i) level of urea and molasses; (ii) crop residue in long or chopped form; (iii) method of application (spraying or incubation); (iv) moisture content of the crop residue; (v) incubation (open or closed); (vi) method of feeding (with or without additional ingredients/supplements); (vii) type of dairy animal; and (viii) farmer objective of production. Previous research indicates that crop residues containing urea-molasses are highly palatable, but are not widely adopted in the study area.

It is also very important to note that cost of feeding is the major part of the total cost of milk production (Singh *et al*., 1993), and hence reduction of feeding cost of dairy cows needs to receive due emphasis. Introduction of improved feeding practices based on strategic supplementation of locally available feed resources is required not only to enhance milk production, but also to introduce sustainable farming practice that will ensure a continuous supply of milk and milk products. Accordingly, designed use urea-molasses treated crop residues for feeding and/or supplementing dairy cattle will have a sound effect, when its inclusion rate in the daily ration is justified both from the biological point of view and financial returns.

Details of information on the incubation (treatment) of crop residues with urea-molasses and utilization practices are not well documented for the study area. Additionally, the cost effective level and system of crop residue incubated with urea-molasses feeding for lactating dairy cows has not been not studied under the study region conditions. As a result, due consideration on the assessment, development and evaluation of feeding options with urea-molasses crop residue based feeding for milk production and other animal performance indices is vital for the study sites. For this reasons this study aims to test the optimum incubation period for urea-molasses treated crop residues and effects on feeding dairy cattle. The target end user is the smallholder dairy farmer and it is hoped that this intervention will increase value or output without adding significant cost hence enhance adoption of urea-molasses for enhancing utilization of crop residues on farms. The **objectives** of the testing will be to:

1. Evaluate the nutritive value and quality of crop residues incubated with urea-molasses at different incubation intervals and establish the optimum incubation time. How well does incubated urea-molasses crop residue keep? At what stage should farmers start using feed?
2. Test and evaluate whether crop residues treatment with urea-molasses can improve nutritive and subsequently feed intake, milk yields and profitability (cost effectiveness) in dairy cows under smallholder dairy feeding practices.

**Hypotheses**

1. The study will test the hypothesis that the nutritive value and quality of crop residues incubated with urea-molasses differs with incubation period. Hence it is important to establish the optimum incubation time in order to produce better quality feed that will enhance adoption of the feed conservation technologies on smallholder farms.
2. That urea-molasses treated crop residues have better nutritive value and subsequently improve feed intake, milk yields (and other body performance parameters) and are cost effective, reducing the costs of feeding dairy cattle on smallholder dairy farms and enhance profitability.

**Materials, Methods and Approach**

**Phase 1 (Objective 1): Evaluate the nutritive value and quality of crop residues incubated with urea-molasses at different incubation intervals and establish the optimum incubation time**

Study Site

This study will be carried out at the Nelson Mandela African Institution of Science and technology (NM-AIST). Samples will be incubated in 2.5kg airtight polythene bags for 90 days, upon which a representative sample from each bag will be processed and shipped to the Institute of Sub-tropical Agriculture, Chinese Academy of Sciences in China for nutritional composition analysis.

Sample Collection

Fresh crop residue samples will be collected in three agro-ecological zones represented by three villages of Babati District, namely: Sabilo/Halu. Seleto/Hysam and Shaurimoyo. These are villages covered by the Africa RISING project in Babati and have abundant crop residues from cropping. They will also be collected from the SIMLESA II project sites of Mbulu District (Tumati, Dongobesh and Hydom Villages) and Karatu District (Rhotia, G-Arusha and Ayalabe villages). The crop residues will comprise:

1. Maize stover 2. Bean Haulms 3. Sunflower straw

4. Pigeon pea haulms 5. Rice straw 6. Groundnut husks

7. Wheat straw

From each of the nine villages, approximately 20kgs will be collected for each crop residue type and apportioned into 5kgs in sugar papers each for transportation. Therefore total samples collected will be 756 (9 villages x 7 crop residue types X 2 treatments- urea + crop residue, urea + molasses + crop residue X 2 urea inclusion levels-1% and 2% x 3 incubation periods-28 days, 45 days and 90 days). However, it’s important to point out that not all these crop residues will be available in the villages as stated. Hence, they will be substituted with what will be available at time of sampling.

Sample Preparation for Incubation

Fresh crop residues are bulky and thus they will be ground (pulverized) on farm using a motorized forage chopper. They will then be weighed using a calibrated weighing scale into 5kg sugar papers. To avoid variance and confounding, each crop residue sample from each village will be put together in a 100kg plastic water tank (hence crop residue samples will be put together by type). They will then be transported to NM-AIST for incubation.

Incubation at NM-AIST-Experimental Design

The ground (pulverized) fresh crop residue samples will be air dried on polythene tubing to rid excess moisture. Each air dried sample crop residue (5kg) will be transferred into a 10kg bucket for treatment with urea-molasses. Fertilizer grade urea (N=46.0% for Tanzania) will be employed for the treatment. The ratio of water-urea or water-urea-molasses solution to the crop residue will be 1:1. At 1% inclusion level of urea, to prepare 5 litres of solution for the 5kg crop residue, 0.125kg urea (N=46%, hence urea concentration of 1.15% in solution) will be added to 5 litres of water and stirred very well until urea is dissolved and clumps of urea disappear from the solution.

For, urea-molasses treatment, 1litre of molasses will be added and stirred very well until the molasses and the urea solution gets mixed up. At 2% inclusion level of urea, to prepare 5litres of solution for the 5kg crop residue, 0.2875kg of urea will be added. Molasses added will remain constant at 1litre. The urea or urea-molasses mixture will be mixed thoroughly with the crop residue in a bucket, the incubated in sealed air tight 5kg polythene tubes. This will then be transferred into 100kg airtight (sealed) water tank containers by crop residue type for incubation. They will be categorized into 28, 45 and 90 incubation periods, replicated three times. The experimental design is summarized I figure 1 below.

**Table 1: Summary of the crop residue incubation experimental design**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | | **Urea Inclusion %** | |  | **Incubation Period** | | |
| **Type of Crop Residue (CR)** | **Quantity of CR (kg)** | **1% Urea (kg)** | **2% Urea (kg)** | **Molasses Additive(L)** | **28 Days** | **45 Days** | **90 Days** |
| Maize stover | 5 | 0.125 | 0.2875 | 1 | 2 | 2 | 2 |
| Bean haulms | 5 | 0.125 | 0.2875 | 1 | 2 | 2 | 2 |
| Sunflower stover | 5 | 0.125 | 0.2875 | 1 | 2 | 2 | 2 |
| Pigeon pea haulms | 5 | 0.125 | 0.2875 | 1 | 2 | 2 | 2 |
| Rice straw | 5 | 0.125 | 0.2875 | 1 | 2 | 2 | 2 |
| Wheat straw | 5 | 0.125 | 0.2875 | 1 | 2 | 2 | 2 |
| Groundnuts husks | 5 | 0.125 | 0.2875 | 1 | 2 | 2 | 2 |

CR=Crop Residue (Control); Treatments = 2 (CRU=Crop Residue + Urea; CRUM=Crop Residue + Urea + Molasses)

The inclusion level of urea (N=46.0%) for this study is 1-2%. However, from previous studies dosage/inclusion of urea from 4-5% on dry matter (DM) has been recommended, but taking into consideration the effect of ammonization and costs.

Sample Analysis

Samples will be shipped to the Institute of Sub-tropical Agriculture, Chinese Academy of Sciences for analysis after last sampling at 90 days. Phytosanitary certificate and clearance for shipping the samples to china will be obtained from the Ministry of Agriculture in Dar es Salaam. The incubated samples will be opened at day 28, 45 and 90.

250gms of the incubated coarse wet material (less than 85% dry matter) will be dried at 55 to 60oC (maximum) in a forced air oven for a maximum of 24 hours to reduce moisture content prior to grinding. The loss of moisture will be recorded (partial dry matter%). The procedure will have minimal effect on chemical composition. The ground material will then be dried at 105oC in a forced air oven for 3 hours. The loss of moisture will also be recorded (laboratory dry matter%). This will be used to determine the total dry matter calculated as:

% Total dry matter % (%DM) = { (Partial dry matter%) X (Laboratory dry matter%) } /100.

The final sample (laboratory dry matter) will be placed in robust ("press-seal") plastic bag and tightly sealed to exclude air, before being shipped to China for further nutritional composition analysis.

**Workplan and Budget**

|  |  |  |  |
| --- | --- | --- | --- |
| Activity | Timeline | By whom | Budget |
| * Sample collection from three agro-ecological zones (villages) from Babati, Mbulu and Karatu Districts | June 2017 | Patrick; Haule; Ngunga | USD 3122 |
| * Sample preparation and incubation at NM-AIST and later shipping to china for analysis | August 2017 | Patrick; Ngunga; Haule; Mpolya | USD 1737 |

*Note: Budget details appended as Excel worksheet.*

**Phase 2 (Objective 2): Test and evaluate whether crop residues treatment with urea-molasses can improve nutritive and subsequently feed intake, milk yields and profitability (cost effectiveness) in dairy cows under smallholder dairy feeding practices**

(Methods and procedures to be developed)

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